CLAIMS

What is claimed:

[c01] A slurry coating composition for providing aluminum content to the surface region of a metal-based substrate, wherein the composition is substantially free of hexavalent chromium, and comprises colloidal silica and particles of an aluminum-based powder.

[c02] The composition of claim 1, wherein the aluminum-based powder has an average particle size in the range of about 0.5 micron to about 200 microns.

[c03] The composition of claim 1, wherein the aluminum-based powder comprises an alloy of aluminum and silicon.

[c04] The composition of claim 3, wherein the silicon is present in an amount sufficient to decrease the melting point of the aluminum-silicon alloy to below about 610°C.

[c05] The composition of claim 3, wherein the silicon is present at a level in the range of about 1% by weight to about 20% by weight, based on the combined weight of the silicon and aluminum.

[c06] The composition of claim 5, wherein the silicon is present at a level in the range of about 10% by weight to about 15% by weight, based on the combined weight of the silicon and aluminum.

[c07] The composition of claim 3, wherein the aluminum-silicon alloy comprises substantially spherical powder particles.

[c08] The composition of claim 1, further comprising a liquid carrier selected from the group consisting of water, alcohols, halogenated hydrocarbon solvents, and compatible mixtures thereof.

[c09] The composition of claim 8, further comprising an effective amount of at least one additive selected from the group consisting of thickening agents, dispersants, deflocculants, anti-settling agents, anti-foaming agents, binders, plasticizers, emollients, surfactants, and lubricants.

[c10] The composition of claim 1, containing less than about 10% by weight of phosphoric acid and phosphoric acid derivatives, based on the weight of the entire composition.

[c11] An aqueous-based slurry coating composition according to claim 1.

[c12] The composition of claim 1, wherein the colloidal silica is present at a level in the range of about 5% by weight to about 20% by weight, based on silica solids as a percentage of the entire composition.

[c13] The composition of claim 1, wherein the amount of aluminum in the slurry composition exceeds the amount of aluminum present in the substrate by up to about 65 atomic %.

[c14] The composition of claim 1, wherein the aluminum-based powder further comprises at least one metal selected from the group consisting of platinum group metals, rare earth metals, scandium, yttrium, iron, chromium, and cobalt.

[c15] The composition of claim 1, wherein the silica in the colloidal silica has an average particle size in the range of about 10 nanometers to about 100 nanometers.

[c16] The composition of claim 1, further comprising at least one organic compound which contains at least two hydroxyl groups.

[c17] The composition of claim 16, wherein the organic compound contains at least three hydroxyl groups.

[c18] The composition of claim 16, wherein the organic compound is selected from the group consisting of alkane diols, glycerol, pentaerythritol, fats, and carbohydrates.

[c19] The composition of claim 18, wherein the carbohydrate is a sugar compound.

[c20] The composition of claim 16, wherein the organic compound is present in an amount sufficient to chemically stabilize the aluminum-based powder during contact with any aqueous component present in the composition.

[c21] The composition of claim 16, wherein the organic compound is present at a level in the range of about 0.1% by weight to about 20% by weight, based on the total weight of the composition.

[c22] A slurry coating composition for providing aluminum to the surface region of a turbine component formed from a material comprising a nickel-based superalloy, wherein the composition is substantially free of hexavalent chromium, and comprises colloidal silica and particles of an aluminum-silicon alloy which has an average particle size in the range of about 1 micron to about 50 microns.

[c23] The composition of claim 22, wherein the colloidal silica is present at a level in the range of about 5% by weight to about 20% by weight, based on silica solids as a percentage of the entire composition; and the amount of aluminum in the composition exceeds the amount of aluminum present in the surface region of the component by up to about 65 atomic %.

[c24] A slurry coating composition for providing aluminum to the surface region of a turbine component formed from a material comprising a

nickel-based superalloy, wherein the composition is substantially free of hexavalent chromium, and comprises colloidal silica; an organic stabilizer which contains at least two hydroxyl groups; and particles of an aluminum-based powder which has an average particle size in the range of about 1 micron to about 50 microns.

[c25] The composition of claim 24, wherein the organic stabilizer is selected from the group consisting of glycerol, at least one dihydroxy alcohol, and combinations thereof.

[c26] The composition of claim 24, wherein the aluminum-based powder comprises an alloy of aluminum and silicon.

[c27] The composition of claim 24, wherein

the organic stabilizer is present at a level in the range of about 0.1% by weight to about 20% by weight, based on the total weight of the composition;

the colloidal silica is present at a level in the range of about 5% by weight to about 20% by weight, based on silica solids as a percentage of the entire composition; and

the amount of aluminum in the composition exceeds the amount of aluminum present in the surface region of the component by up to about 65 atomic %.

[c28] A method for aluminiding the surface region of a metal substrate, comprising the following steps:

(I) applying at least one layer of a slurry coating to the surface of the substrate; wherein the slurry coating is substantially free of hexavalent chromium, and comprises colloidal silica and particles of an

aluminum-based powder, and the aluminum-based powder has an average particle size in the range of about 0.5 micron to about 200 microns; and

(II) heat treating the slurry coating, under conditions sufficient to remove volatile components from the coating, and to cause diffusion of aluminum into the surface region of the substrate.

[c29] The method of claim 28, wherein the aluminum-based powder in the slurry coating comprises an alloy of aluminum and silicon.

[c30] The method of claim 28, wherein the slurry coating further comprises an organic stabilizer which contains at least two hydroxyl groups.

[c31] The method of claim 30, wherein the organic stabilizer is selected from the group consisting of alkane diols, glycerol, pentaerythritol, fats, and carbohydrates.

[c32] The method of claim 30, wherein the aluminum-based powder in the slurry coating comprises an alloy of aluminum and silicon.

[c33] The method of claim 28, wherein the slurry coating is applied to the surface of the substrate by a technique selected from the group consisting of spraying, slip-casting, brush-painting, dipping, pouring, rolling, and spin-coating.

[c34] The method of claim 28, wherein the heat treatment of step (II) comprises a preliminary heat treatment to remove the volatile components, and a final heat treatment to diffuse the aluminum into the substrate.

[c35] The method of claim 28, wherein the heat treatment is carried out at a temperature in the range of about 650°C to about 1100°C.

[c36] The method of claim 28, wherein step (II) comprises a graduated heat treatment.

[c37] The method of claim 28, wherein the surface region of the substrate extends to a depth of about 200 microns into the substrate.

[c38] A method for aluminiding the surface region of a nickel-based superalloy substrate, comprising the following steps:

(I) spraying at least one layer of a slurry coating on the surface of the substrate; wherein the slurry coating is substantially free of hexavalent chromium, and comprises colloidal silica; particles of an aluminum-based powder; and an organic stabilizer, wherein the aluminum-based powder has an average particle size in the range of about 0.5 micron to about 200 microns; and the organic stabilizer is selected from the group consisting of alkane diols, glycerol, pentaerythritol, fats, and carbohydrates; and then

(II) heat treating the slurry coating in an oven at a temperature of about 650°C to about 1100°C, so as to remove volatile components from the coating, and to cause diffusion of aluminum into the surface region of the substrate;

wherein the organic stabilizer is present at a level in the range of about 0.1% by weight to about 20% by weight, based on the total weight of the composition;

the colloidal silica is present at a level in the range of about 5% by weight to about 20% by weight, based on silica solids as a percentage of the entire composition; and

the amount of aluminum in the composition exceeds the amount of aluminum present in the substrate by up to about 65 atomic %.

[c39] The method of claim 38, wherein the substrate is a turbine engine component.

[c40] A method for preparing an aluminum-based slurry coating composition, comprising the following steps:

a) combining an organic stabilizer with an aluminum-based powder, in the presence of a limited amount of aqueous colloidal silica, so as to form a uniform, stabilizer-aluminum pre-blend, wherein the amount of aqueous colloidal silica present is high enough to ensure adequate blending of the stabilizer and the aluminum-based powder, but low enough to ensure that the pre-blend remains chemically-stabilized; and then

b) combining a second portion of the aqueous colloidal silica with the stabilizer-aluminum pre-blend formed in step (a), to form a chemically-stable slurry coating composition.

[c41] A metal substrate, having a slurry coating disposed on its surface, said coating being free of hexavalent chromium, and comprising colloidal silica and particles of an aluminum-based powder.

[c42] The metal substrate of claim 41, wherein the aluminum-based powder comprises an alloy of aluminum and silicon.

[c43] The metal substrate of claim 41, wherein the slurry coating further comprises at least one organic compound which contains at least two hydroxyl groups.

[c44] The metal substrate of claim 41, comprising a turbine engine component formed of a nickel-based superalloy.